

The yield curve as a predictor of recessions in the United States and Europe

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Introduction

Economists often use complex mathematical models to forecast the path of the US economy and the likelihood of recession. But simpler indicators such as interest rates, stock price indexes, and monetary aggregates also contain information about future economic activity. In this paper, we examine the usefulness of one such indicator - the yield curve, that is, the spread between long and short-term interest rates.

Our analysis differs in two important respects from earlier studies of the predictive power of financial variables.¹ First, we focus simply on the ability of these variables to forecast recessions rather than on their success in producing quantitative measures of future economic activity.² We believe this is a useful approach because signs of an oncoming recession are always of concern to policymakers and market participants. Second, instead of focusing solely on in-sample performance, we also focus on out-of-sample performance, that is, accuracy in predictions for quarters beyond the period over which the model is estimated. This is particularly important because out-of-sample performance provides a much truer picture of how well an indicator will do when it is actually used in a real world forecasting exercise.

1. Why consider the yield curve?

For several reasons, the steepness of the yield curve should be an excellent indicator of a possible future recession. First, current monetary policy has a significant influence on the yield curve spread and hence on real activity over the next several quarters. A rise in the short rate would tend to flatten the yield curve as well as slow real growth in the near term. Although this relationship is very likely part of the story, it is not the whole story.³ Expectations of future inflation and real interest rates contained in the yield curve spread seem to play an important additional role in the prediction of future activity. The yield curve spread variable we examine here corresponds to a forward interest rate applicable from three months to ten years into the future. As explained in Mishkin (1990a, 1990b), this rate can be decomposed into expected real interest rate and expected inflation components, each of which may be helpful in forecasting real growth. The expected real rate may be associated with expectations of future monetary policy. Moreover, because inflation tends to be

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- 1 Papers that examine the predictability of future real activity include Palash and Radecki (1985), Harvey (1988), Laurent (1988, 1989), Diebold and Rudebusch (1989), Estrella and Hardouvelis (1990, 1991), Chen (1991), Hu (1993), Bomhoff (1994), Davis and Henry (1994), Plosser and Rouwenhorst (1994), Barran et al. (1995), Davis and Fagan (1995), Estrella and Mishkin (1995). Papers that examine the predictability of future inflation include Mishkin (1990a, 1990b, 1991) and Jorion and Mishkin (1991).
 - 2 Stock and Watson (1989, 1992) and Watson (1991) also focus on predicting recessions. Boldin (1994), in an alternative approach, models recessions using a regime-switching formulation. In a recent paper, Reinhart and Reinhart (1996), using very different methods than in this paper, find that the best predictors of recession in Canada are the US and Canadian term structure spread, a conclusion that is similar to the one found in this paper.
 - 3 The analysis in Estrella and Hardouvelis (1990,1991) and Estrella and Mishkin (1995) suggests why the yield curve contains information beyond that related to monetary policy.

positively related to activity, the expected inflation component may be informative about future real growth.

2. Estimating the probability of recession

To assess how well each indicator variable predicts recessions, we use the so-called probit model, in which the probability of being in a recession is directly related to a specific explanatory variable such as the yield curve spread.⁴ To see how the model works, consider the results of one of the most successful models in the article which estimates the probability of being in a recession four quarters in the future in the United States as a function of the current value of the yield spread between the ten-year Treasury note and the three-month Treasury bill. (The model is estimated using data from the first quarter of 1960 to the first quarter of 1995.) Table 1 shows the values of this yield curve spread that correspond to estimated probabilities of a US recession four quarters in the future. As the table indicates, the estimated probability of a recession four quarters ahead estimated from this model is 10 percent when the spread averages 0.76 percentage points over the quarter, 50 percent when the spread averages -0.82 percentage points, and 90 percent when the spread averages -2.40 percentage points.

Table 1
Estimated US recession probabilities for probit model using the yield curve spread
Four quarters ahead

Recession probability (percent)	Value of spread (percentage points)
5	1.21
10	0.76
15	0.46
20	0.22
25	0.02
30	-0.17
40	-0.50
50	-0.82
60	-1.13
70	-1.46
80	-1.85
90	-2.40

Note: The yield curve spread is defined as the spread between the interest rate on ten-year US Treasury note and the three-month US Treasury bill.

The usefulness of the model can be illustrated through the following examples. Consider that in the third quarter of 1994, the spread in the United States averaged 2.74 percentage points. The corresponding predicted probability of recession in the third quarter of 1995 was only 0.2 percent, and indeed, a recession did not materialise. In contrast, the spread averaged -2.18 percentage points in the first quarter of 1981, implying a probability of recession of 86.5 percent four quarters later. As

4 For a technical discussion of this model and how it is estimated, see Estrella and Mishkin (1996). The economy is designated as "in recession" starting with the first quarter after a business cycle peak and continuing through the trough quarter. The peak and trough dates are the standard ones issued by the National Bureau of Economic Research (NBER) and used in most business cycle analysis. These dates are not without controversy, however, because the NBER methodology makes implicit assumptions in arriving at these dates.

predicted, the first quarter of 1982 was in fact designated a recession quarter by the National Bureau of Economic Research (NBER).

3. Results for the United States

Although the yield curve has advantages as a predictor of future economic events, several other variables have been widely used to forecast the path of the economy. Among financial variables, stock prices have received much attention. Finance theory suggests that stock prices are determined by expectations about future dividend streams, which in turn are related to the future state of the economy. Among macroeconomic variables, the Commerce Department's (now the Conference Board's) index of leading economic indicators appears to have an established performance record in predicting real economic activity. Nevertheless, its record has not always been subjected to careful comparison tests. In addition, because this index has often been revised after the fact to improve its performance, its success could be overstated. An alternative index of leading indicators, developed in Stock and Watson (1989), appears to perform better than the Commerce Department's index of leading economic indicators. In the discussion below, we compare the predictive power of these three variables for US recessions with that of the yield curve.⁵

Using the probit model estimates, we can compare how well the yield curve forecasts US recessions with that of the New York Stock Exchange (NYSE) stock price index, the Commerce Department's index of leading economic indicators, and the Stock-Watson index. Charts 1-8 plot the forecasted probabilities of a recession in the United States for one, two, four, and six quarters in the future and the actual periods of recession (shaded in the charts).⁶ To understand how to read these charts, consider the forecast for the fourth quarter of 1990, which is the first quarter after the peak of the business cycle and is thus at the start of the last shaded recession region on the charts. In Chart 1, which shows the forecast one quarter ahead, the probability of recession from the probit model using the yield curve spread variable (SPREAD) forecasted in the third quarter of 1990 for the fourth quarter of 1990 is 13 percent. Similarly, in Chart 7, which shows forecasts six quarters ahead, the forecasted probability of recession for the fourth quarter of 1990 - 22 percent - is generated from a model using the yield curve spread as of the second quarter of 1989.

5 In Estrella and Mishkin (1996), we have examined in detail the predictive ability of these and other variables, including interest rates by themselves, other stock market indexes, interest rate spreads, monetary aggregates (both nominal and real), the component series of the index of leading economic indicators, and an additional experimental index of leading indicators developed in Stock and Watson (1992). Of all the variables, the four singled out in this article have the best ability to predict recessions.

6 Note that the forecasts in these charts are true out-of-sample results which have been obtained in the following way: First, a given model is estimated using past data starting with the first quarter of 1959 up to a particular date, say the first quarter of 1970. Then these estimates are used to form the forecasts, say four quarters ahead. In this case, the projection would apply to the first quarter of 1971. After adding one more quarter to the estimation period, the procedure is repeated. That is, data up to the second quarter of 1970 are used to make a forecast for the second quarter of 1971. In this way, the procedure mimics what a forecaster would have predicted with the information available at any point in the past.

Chart 1
Probability of recession in the United States, one quarter ahead

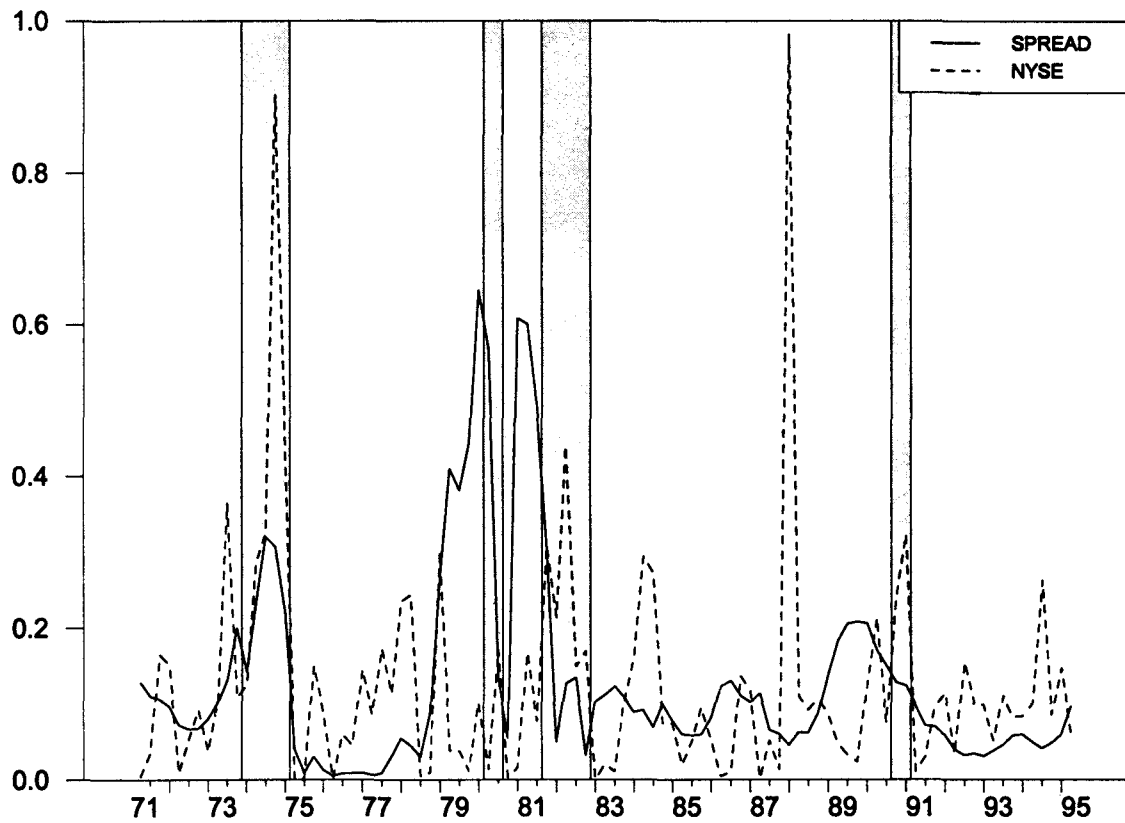


Chart 2
Probability of recession in the United States, one quarter ahead

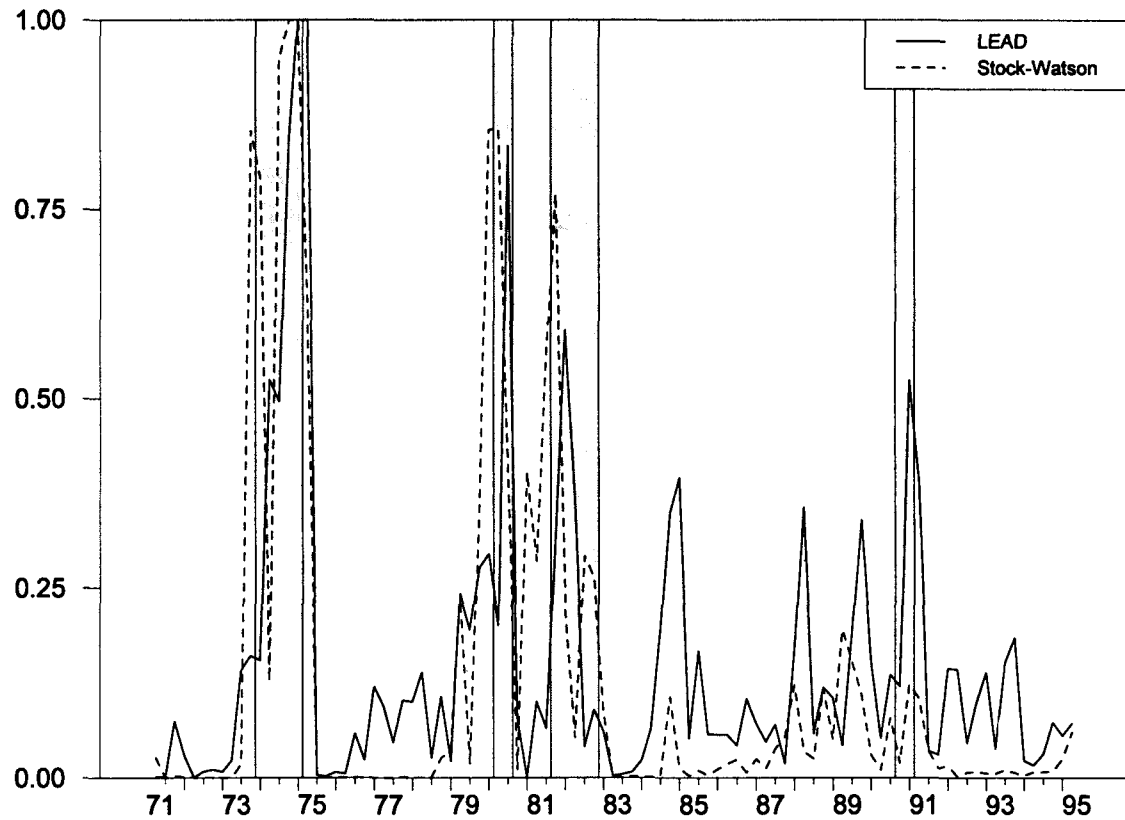


Chart 3
Probability of recession in the United States, two quarters ahead

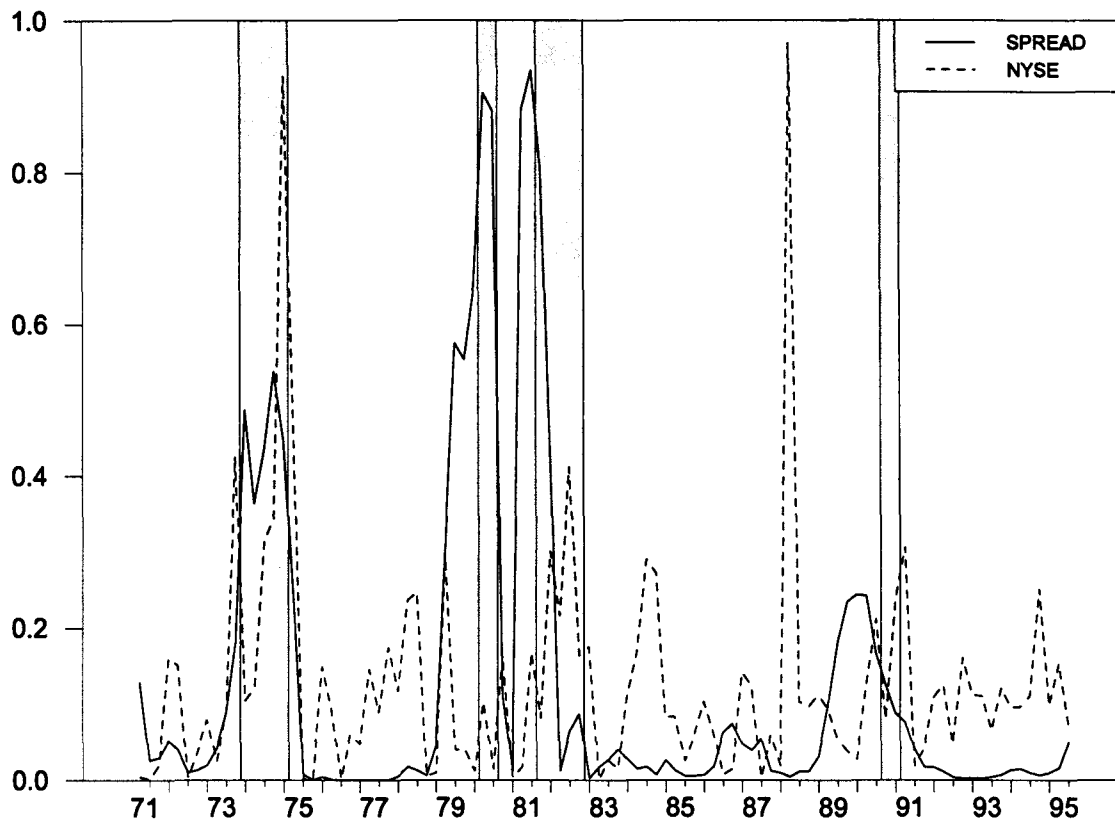


Chart 4
Probability of recession in the United States, two quarters ahead

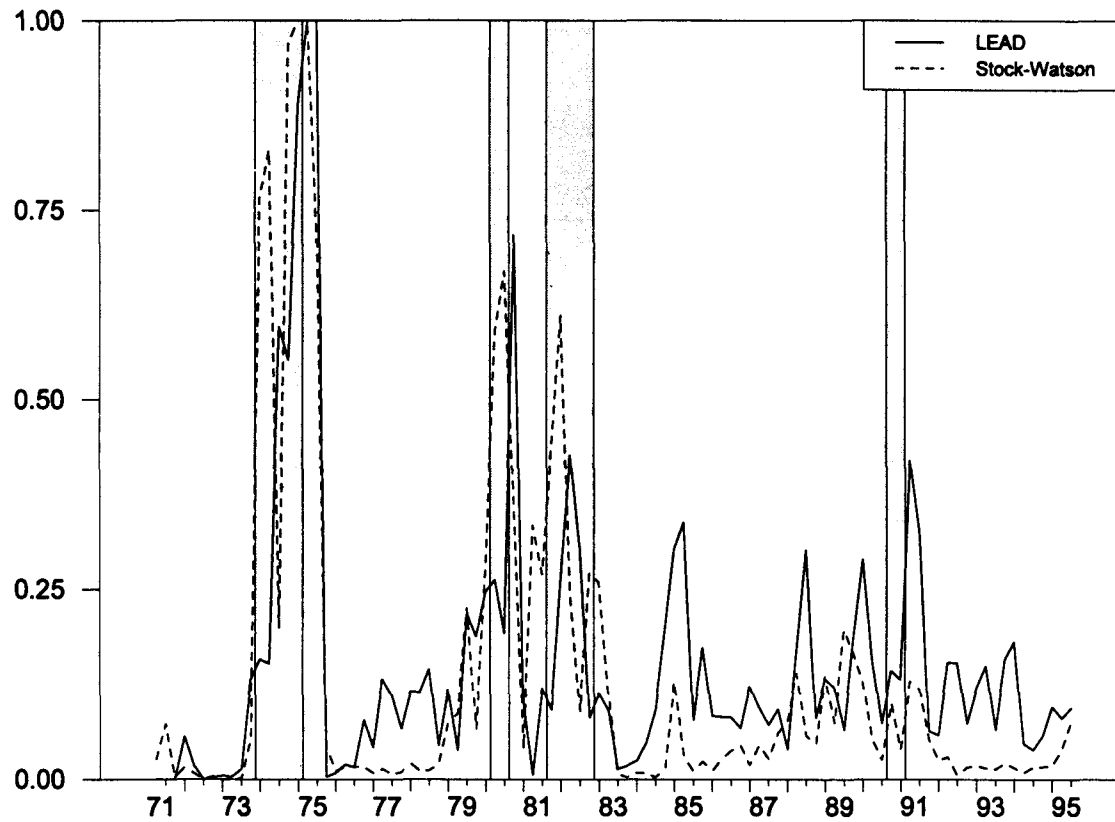


Chart 5
Probability of recession in the United States, four quarters ahead

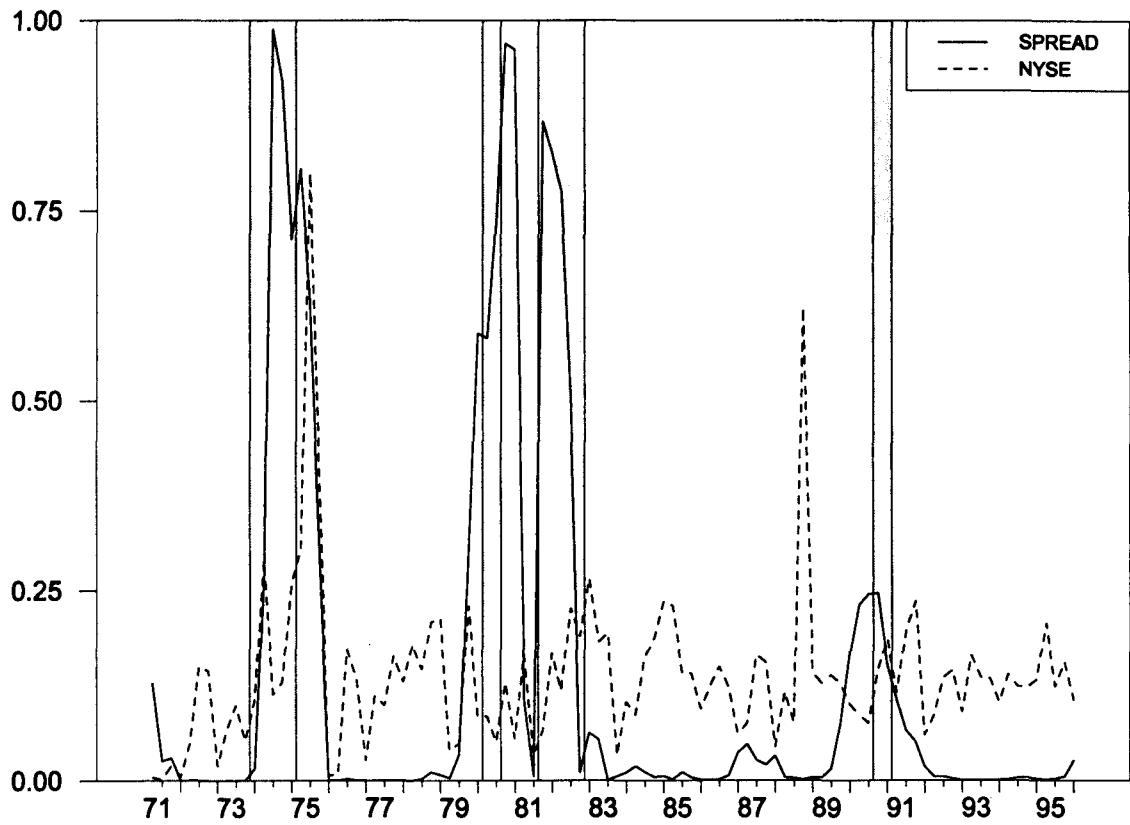


Chart 6
Probability of recession in the United States, four quarters ahead

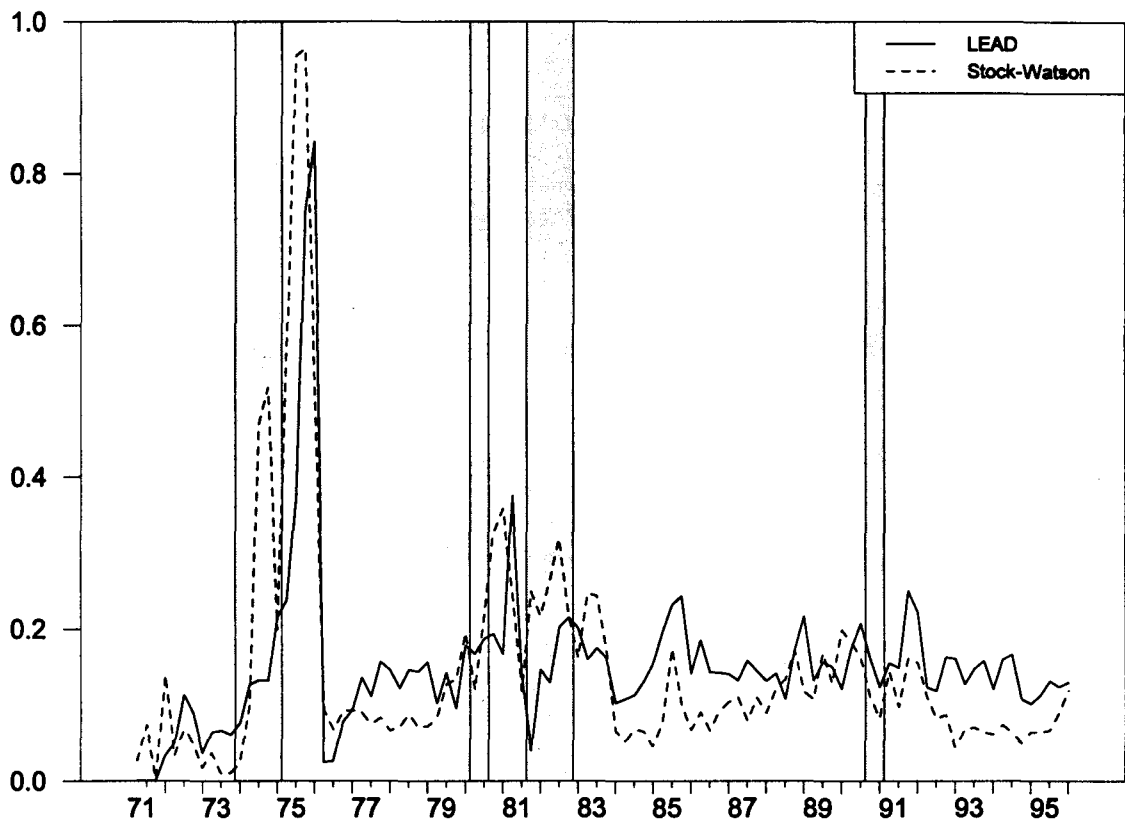


Chart 7
Probability of recession in the United States, six quarters ahead

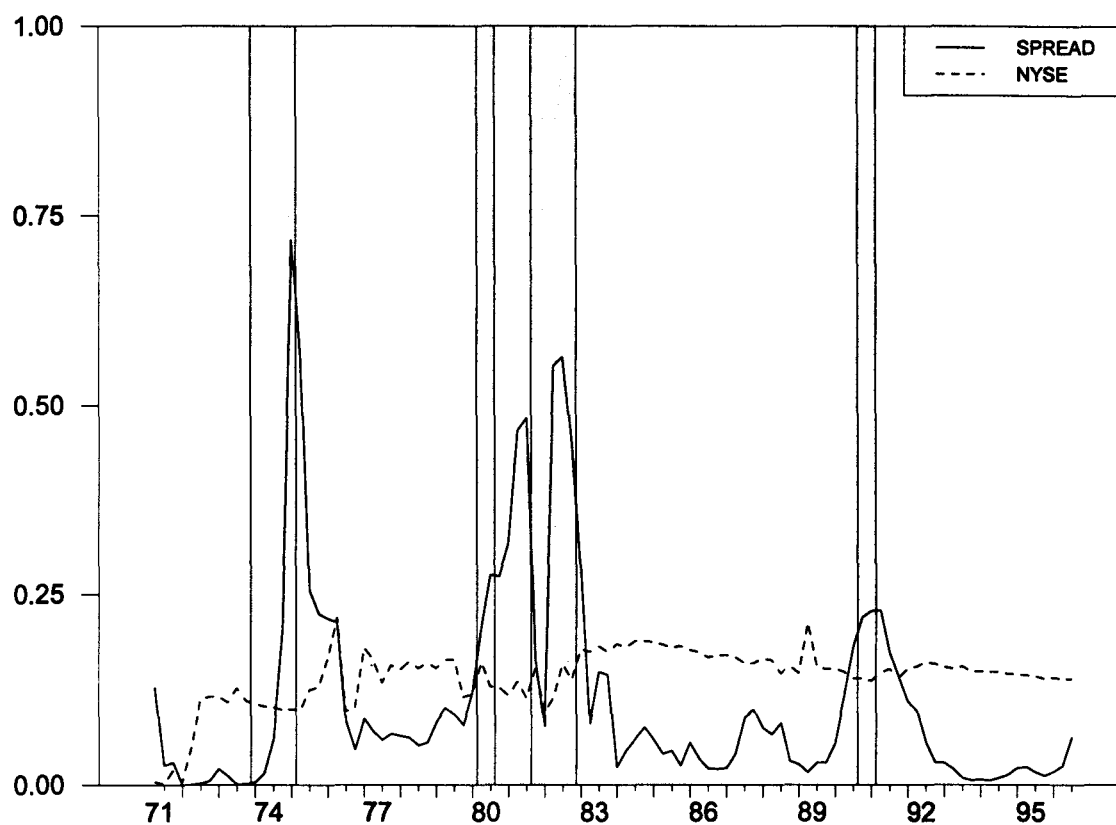
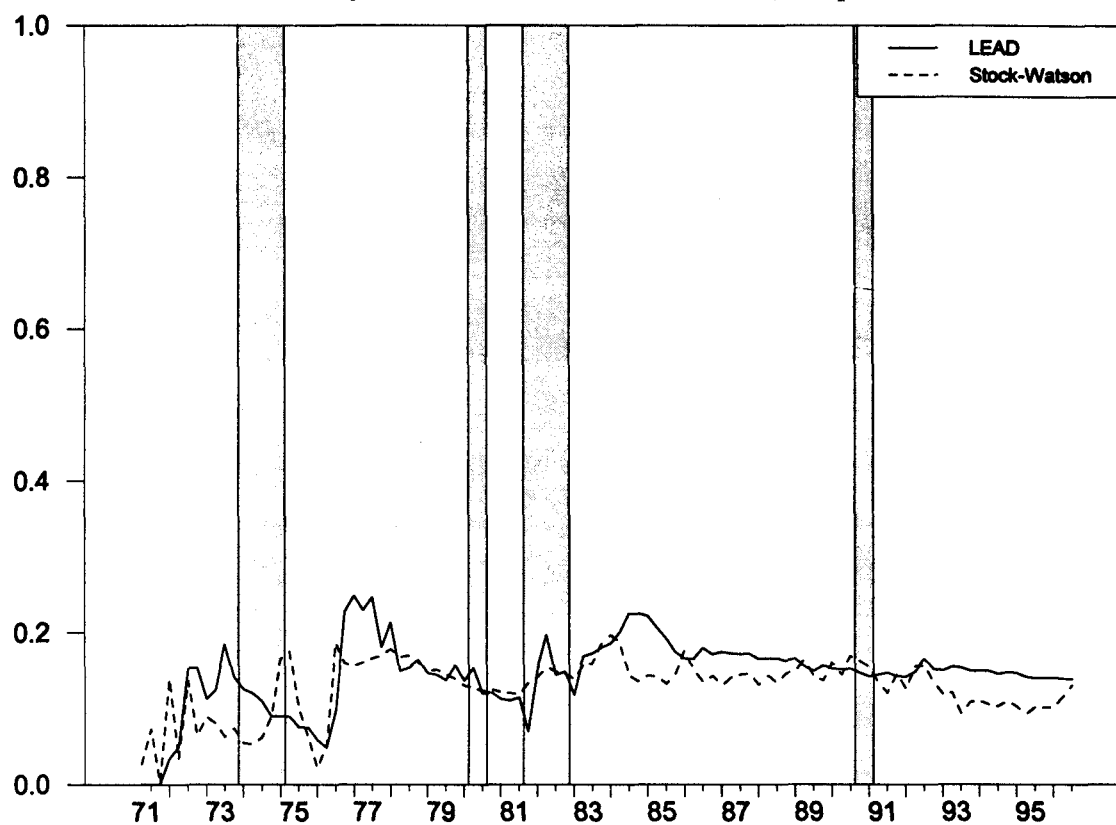


Chart 8
Probability of recession in the United States, six quarters ahead



In assessing these charts, we must also understand that even a probability of recession that is considerably less than one can be a strong signal of recession. Because in any given quarter the probability of recession is quite low, a forecasted probability of, say, 50 percent is going to be quite unusual. Indeed, the successful forecasting model described in the table yields probabilities of recession that are typically below 10 percent in nonrecession (unshaded) periods (Chart 5). Thus, even a probability of recession of 25 percent - the figure forecast for the fourth quarter of 1990 from data on the yield curve spread one year earlier - was a relatively strong signal in the fourth quarter of 1989 that a recession might come one year in the future.

The charts invite two basic conclusions about the performance of our four variables:⁷

- Although all the variables examined have some forecasting ability one quarter ahead, the leading economic indicator indices, particularly the Stock-Watson index, produce the best forecasts over this horizon.
- In predicting recessions two or more quarters in the future, the yield curve dominates the other variables, and this dominance increases as the forecast horizon grows.

Let's look in more detail at the probability forecasts in Charts 1-8. Charts 1 and 2 show that the indexes of leading economic indicators typically outperform the yield curve spread and the NYSE stock price index for forecasts one quarter ahead. For the 1973-75, 1980, and 1981-82 recessions, both indices of leading economic indicators, and particularly the Stock-Watson index, are quite accurate, outperforming the yield curve spread and the NYSE stock price index with a high predicted probability during the recession periods. However, despite excellent performance in these earlier recessions, the Commerce Department indicator provides several incorrect signals in the 1982-90 boom period and the Stock-Watson index completely misses the most recent recession in 1990-91.⁸ Although the financial variables - the yield curve spread and the NYSE stock price index - are not quite as accurate as the leading economic indicators in predicting the 1973-75, 1980, and 1981-82 recessions, they do provide a somewhat clearer signal of an imminent recession in 1990.

As the forecasting horizon lengthens to two quarters ahead and beyond, the performance of the NYSE stock price index and the leading economic indicator indexes deteriorates substantially (Charts 3-8). Indeed, at a six quarter horizon, the probabilities estimated using the three indexes are essentially flat, indicating that these variables have no ability to forecast recessions. By contrast, the performance of the yield curve spread improves considerably as the forecast horizon lengthens to two and four quarters. The estimated probabilities of recession for 1973-75, 1980, and 1981-82 based on the yield curve spread are substantially higher than at the one-quarter horizon, and the signal for the 1981-82 recession no longer comes too early (compare Charts 3 and 5 with Chart 1).

Furthermore, in contrast to the other variables, the yield curve spread does give a relatively strong signal in forecasting the 1990-91 recession four quarters ahead. Although the forecasted probability is lower than in previous recessions, it does reach 25 percent (Chart 5). There are two reasons why the signal for this recession may have been weaker than for the earlier recessions. First, restrictive monetary policy probably induced the 1973-75, 1980-81, and 1981-82 recessions, but played a much smaller role in the 1990-91 recession. Because the tightening of monetary policy also affects the yield curve, we would expect the signal to be more pronounced at such times. Second, the

7 Note that all conclusions drawn from looking at the charts are confirmed by more precise statistical measures of out-of-sample fit in Estrella and Mishkin (1996).

8 These results have already been noted in very useful postmortem analyses by Watson (1991) and Stock and Watson (1992).

amount of variation in the yield curve spread has changed over time and was much less in the 1990s than in the early 1980s, making a strong signal for the 1990-91 recession difficult to obtain.⁹

When we look at how well the yield curve spread forecasts recessions six quarters in the future (Chart 7), we see that the performance deteriorates from the four-quarter-ahead predictions. Nonetheless, unlike the other variables considered, the yield curve spread continues to have some ability to forecast recessions six quarters ahead.

4. Results for Europe

Given the results for the United States which indicate that the yield curve spread has its best forecasting performance four quarters ahead, we examine how well the domestic yield curve spreads for France, Germany, Italy and the United Kingdom perform in predicting recessions in these countries four quarters in the future.¹⁰ For each of these countries, Chart 9 provides the forecasted probabilities of recessions four quarters in the future together with the actual periods of recession in shaded areas.¹¹ Since we cannot estimate models and then perform out-of-sample forecasts with less than ten years of data and our sample for the European countries only starts in 1974, Chart 9 differs from the previous charts in that it only shows out-of-sample forecasts beginning in 1985. Because there is thus a very short sample period for the out-of-sample forecasts, the chart also provides in-sample estimates of the recession probabilities. To ensure comparability, the US results are also reported using the same sample period as for the European countries.

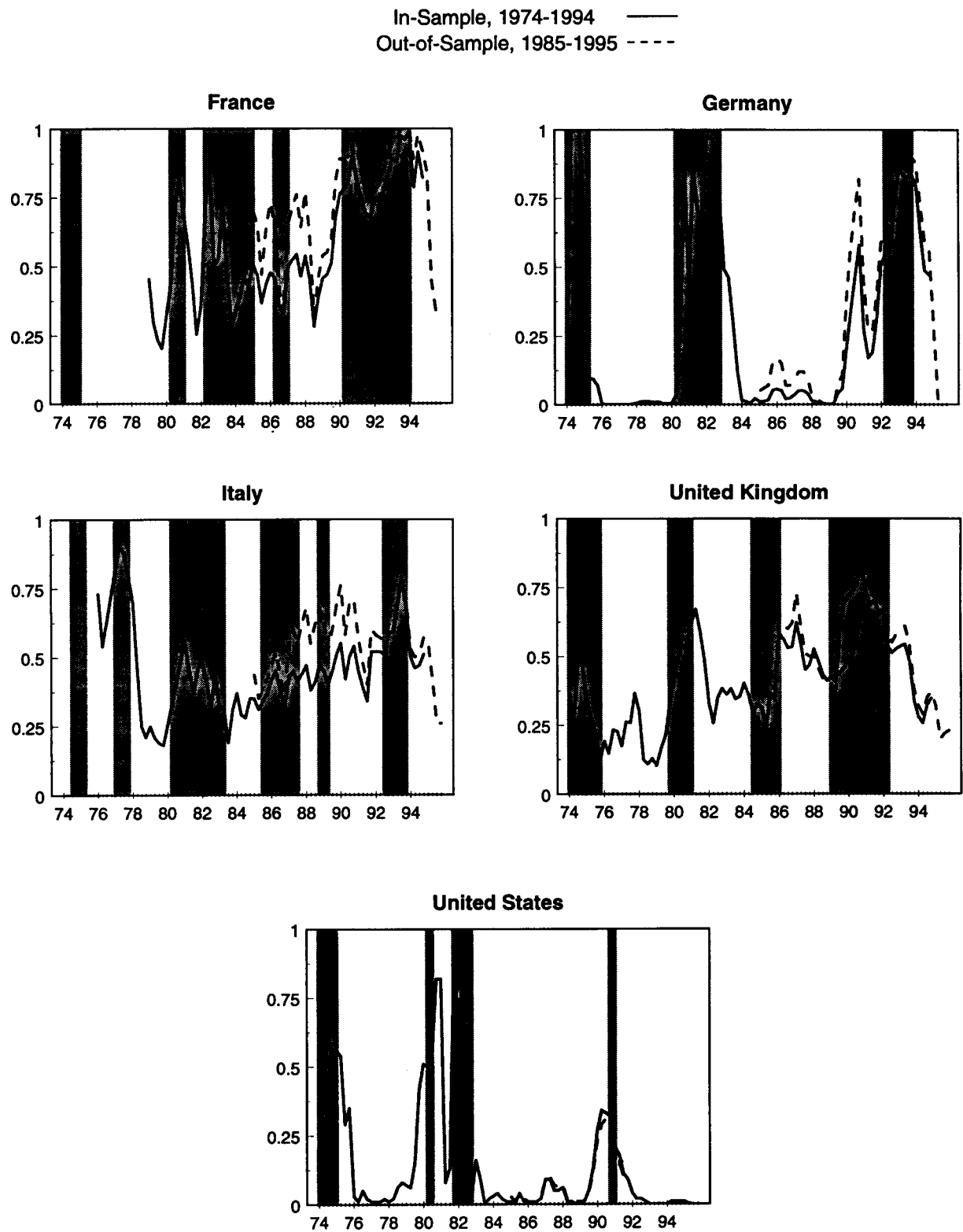
As we can see in Chart 9, the out-of-sample forecasts are generally quite close to those of the in-sample forecasts; thus it is reasonable to look at the in-sample results in addition to the out-of-sample results to assess the yield curve's forecasting performance in these countries. The yield curve spread seems to have some ability to forecast recessions in all these countries and formal statistical measures confirm this. Particularly striking are the results for Germany which indicate that the German yield curve spread has been an accurate forecaster of German recessions; as in the United States, forecasted probabilities of recession are low during nonrecession periods and the probabilities reached during recession periods are even higher than in the United States. The results for the United Kingdom are also quite good, but are not quite as strong as in the United States or Germany. Peaks in the forecasted probabilities are more prone to be late and estimated recession probabilities are often fairly high in nonrecession periods. The results for France and Italy are weaker than in the other

9 Another potential explanation is that the 1990-91 recession was relatively mild and so a weaker signal might be expected. However, as shown in Estrella and Hardouvelis (1991), the yield curve spread also provides much weaker signals for recessions in the 1950s, even though they were not mild. Furthermore, the signal for the 1969-70 recession is strong, although the recession itself was mild. Thus the severity of the recessions does not seem to be associated with the strength of the signal from the yield curve.

10 The yield curve spreads for each country are comparable to those for the United States. For France the yield curve spread is the interest rate on long term public and semi-public sector bonds, secondary market minus the 3-month Paris interbank offer rate; for Germany, the interest rate on 10-year, federal public bonds, secondary market, minus 3-month loan rate; for Italy, the interest rate on Treasury bonds, net of tax, secondary market, minus the interest rate on 3-month ordinary Treasury bills, gross of tax; and for the United Kingdom, the interest rate on 10-year, medium dated, government stocks, minus the 91-day Treasury bill, average allotment rate. Bernard and Gerlach (1995) conduct a similar exercise for France, Germany and the United Kingdom and also find that foreign yield curve spreads have additional explanatory power in forecasting recessions in some cases.

11 For the European countries, the economy is designated as "in recession" starting with the first quarter after a business cycle peak and continuing through the trough quarter. The peak and trough dates for each of these countries are from the following sources suggested in Bernard and Gerlach (1995): France, Allard (1994, p. 28, Table 2); Germany, Deutsche Bundesbank (1995, p. 86); Italy, Center for International Business Cycle Research, Columbia University; United Kingdom, Central Statistical Office (1995, p. T76).

Chart 9
Probability of recessions with yield curve spread, four quarters ahead



countries. The differences between probabilities in recession and nonrecession periods for France and Italy are less than in the other countries and there are more false signals of recession when recession probabilities rise above one-half during nonrecession periods. These weaker results are not too surprising because there may be substantial measurement error in recession dates for these countries, as is evidenced by disagreements about the appropriate recession dates for European countries.¹²

Conclusion

This article has examined the performance of the yield curve spread and several other financial and macroeconomic variables in predicting future recessions. The results obtained from a model using the yield curve spread are encouraging and suggest that the yield curve spread can have a useful role in macroeconomic prediction, particularly with longer lead times. Because forecasters and policymakers care more about longer term forecasts, the fact that the yield curve strongly outperforms other variables at longer forecasting horizons makes its use as a tool in the forecaster's toolbox even more compelling.

With the existence of large-scale macroeconometric models and with the judicious predictions of knowledgeable market observers, why should we care about the predictive ability of the yield curve? There is no question that judgmental and macroeconometric forecasts are quite helpful. Nevertheless, the yield curve can usefully supplement large econometric models and other forecasts for three reasons. First, forecasting with the yield curve has the distinct advantage of being quick and simple. With a glance at long-term bond and three-month bill rates on the computer screen, anyone can compute a probability forecast of recession almost instantaneously by using a table such as ours. Second, a simple financial indicator such as the yield curve can be used to double-check both econometric and judgmental predictions by flagging a problem with the results of more involved approaches. On the one hand, if forecasts from an econometric model and the yield curve agree, confidence in the model's results can be enhanced. On the other hand, if the yield curve indicator gives a different signal, it may be worthwhile to review the assumptions and relationships that led to the prediction. Third, using the yield curve to forecast with the framework outlined here provides a forecasted probability of a future recession, a probability that is of interest in its own right.

¹² For example, the Center for International Business Cycle Research (CIBCR) at Columbia University has quite different recession dates for France than the Allard (1994) source we use here. European economists have indicated to us that the Allard (1994) dates are more accurate than the CIBCR dates and we do find better results with the Allard (1994) dates.

Notes to Charts 1-8

Source: Authors' calculations

Notes: The probabilities in these figures are derived from out-of-sample forecasts, one, two, four and six quarters ahead. For example, the forecasted probabilities in charts 1 and 2 are for one quarter ahead - that is, the probability shown is a forecast for the contemporaneous quarter, using data from 1 quarter earlier - while for charts 7 and 8, the forecasted probabilities are for six quarters ahead. SPREAD denotes the forecasts from the model using the yield curve spread (the difference between the interest rate on ten-year Treasury bonds and on three-month Treasury bills, both on a bond-equivalent basis) as the explanatory variable. NYSE denotes the results from the model using the quarterly percentage change in the NYSE stock price index as the explanatory variable. LEAD denotes the forecasts from the model using the quarterly percentage change in the Commerce Department's index of leading indicators as the explanatory variable, while Stock-Watson denotes the forecasts using the quarterly percentage change in the Stock-Watson (1989) leading economic indicator index. Shaded areas designate "recessions" starting with the first quarter after a business cycle peak and continuing through the trough quarter. The peak and trough dates are the standard ones issued by the National Bureau of Economic Research.

Notes to Chart 9

The probabilities in these figures are for forecasts four quarters ahead using a probit model with the yield curve spread (as defined in footnote 10) as an explanatory variable; that is, the probability shown is a forecast for the contemporaneous quarter, using data from four quarters earlier. The economy is designated as "in recession" starting with the first quarter after a business cycle peak and continuing through the trough quarter. The peak and trough dates for each of these countries are from the following sources: France, Allard (1994, p. 28, Table 2); Germany, Deutsche Bundesbank (1995, p. 86); Italy, Center for International Business Cycle Research, Columbia University; United Kingdom, Central Statistical Office (1995, p. T76).

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Comments on paper by A. Estrella and F. S. Mishkin by Stefan Gerlach (BIS)

During the last few years there has been considerable increase in central bank interest in the term structure of interest rate as an indicator for monetary policy purposes. There are essentially five factors that explain this interest:

- First, the slope of the term structure has been shown in a number of studies, using data for different time periods and countries, to contain considerable information about the future path of short term interest rates, inflation rates and real economic growth.
- Second, since interest rates are essentially instantaneously observed, the term structure provides immediate information about changes in financial market participants' expectations about the future path of the economy. This is particularly important in conditions of large discrete changes in economic policy, such as the announcement of a new fiscal plan, or a change in the exchange rate regime.
- Third, interest rate data are not subject to data revisions. The common problem of forecasting changes in economic conditions on the basis of preliminary estimates – that are likely to be reversed to an unknown extent in an unknown direction – of macroeconomic data is therefore avoided.
- Fourth, since yields are observed on financial instruments that may have long maturities – 10 years or even more – it is possible to provide estimates of financial market participants' expectations for long time horizons. Such information is difficult to come by in other ways.
- Fifth, expectations of the future embodied in interest rates constitute large bets by market participants about the future path of the economy. Needless to say, market participants have very good reasons for trying to get those guesses right. This is not necessarily the case for answers to surveys of market expectations.

The paper by Estrella and Mishkin demonstrates, as the authors have done together and with other co-authors elsewhere, that the term-structure of interest rates contains information that is useful in predicting the likelihood of a future recession in the United States and in four European countries. While the findings reported in the paper are of considerable interest to monetary policy makers, I have two concerns with the paper.

First, the results presented stem from estimated probit models, which can be thought of as a (non-linear) regressions in which the dependent variable takes the value of 1 if a recession occurred and 0 otherwise. One aspect of this approach is the fact that it uses the data inefficiently. To see this, note that instead of using, say, the growth rate of GDP as the dependent variable, the observations are grouped into low growth (recession) and high-growth (non-recession) quarters. Thus, much of the "detail" in the data is disregarded.¹³ Since forecasts of the future real growth rates can be used to construct estimates of the likelihood of a recession, the authors' argument that "...recessions are always of concern to policy makers and market participants..." does not explain their choice of technique, however persuasive it may be.

Second, while the authors demonstrate that the slope of the yield curve contains information about future real economic conditions, they do not explain why it does so. The authors indicate that there are two possible answers. First, the relationship may be due to *expectations*: financial market participants that expect a recession to come may quite naturally expect inflation to subside, and short-term interest rates to fall in response to a relaxation of monetary policy. If this is

¹³ Probit techniques are typically used when it is difficult to quantify the dependent variable, or when it can only take two values. This is not the case here.

the case, the relationship could very well shift if it was used in the conduct of policy. Second, the relationship may be *causal*: a negatively sloped yield curve may be a reflection of tight monetary policy which in turn will lead to a slow-down in economic activity in the future. In this case the relationship is structural and can be used for policy purposes. In particular, the slope of the yield curve can be used as a measure of how tight policy is. Since it is likely that the correlation between the current slope of the yield curve and future real economic conditions is due to both expectation and causal factors, it would seem desirable to have a clearer sense of their relative importance before the relationship is exploited for policy purposes.